Ground Water Sustainability

State of the Estuaries Conference
October 20-21, 2003

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Today's Topics:

- Definition of sustainability (emphasis on ground water)
- Ground water occurrence
- Sustainability "variables"
- Steps toward achieving sustainability?

Definition of Sustainability:

- First use of term "sustainability" used to explain steady-state economy in the 1970's (Wood, 2001)
- The ability to meet the needs of the present generation without compromising the ability of future generations to meet their needs. (United Nations 1987)
- Development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences.
 (Alley and others, 1999)

But what are our water "needs"?

- Only 2-3 liters per day needed for survival
- In the U.S.: It takes 1,000 tons of water to produce 1 ton of wheat
- It takes 10,000 tons of water for 1 ton of beef
- We use 2,000 m^3/y/person (not including hydroelectric)

(Wood, 2001)

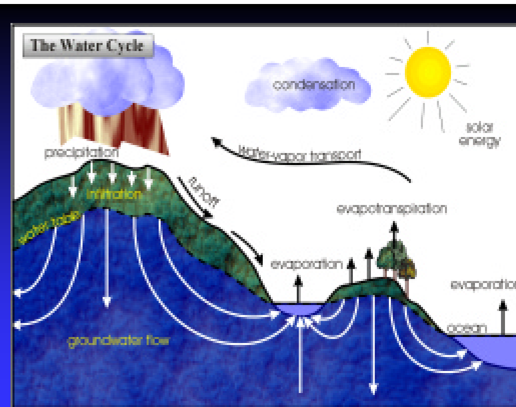
But what are our water needs?

- Science vs. Policy
- Science can explore the implications of different interpretations of sustainability, but it can not choose the "correct" interpretation for society
 (Sophocleous, 2000, J. of Hydrology)

What do we need to do to achieve sustainability?

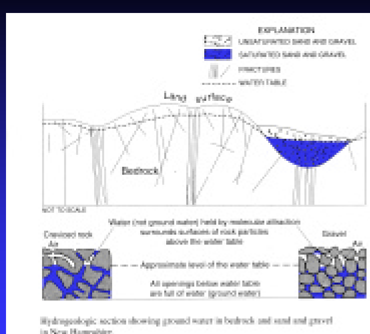
- Understand and quantify our water resources and assess future demands
- Evaluate and optimize the way we use water

Ground Water Occurrence



(USGS, 2000)

In NH, ground water occurs mainly in bedrock fractures and unconsolidated gravel deposits



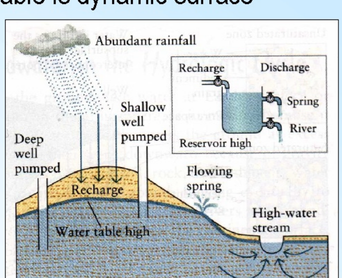
(Modified from USGS, 1998)

Glacial Lake Delta Deposit

(www.state.me.us/doc/nrimc/mgs/mgs.htm)

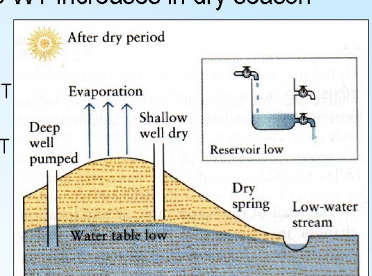
Water table is dynamic surface

- Slope & elevation reflect balance of discharge & recharge
- recharge > discharge
  - depth to WT decreases
  - slope of WT increases



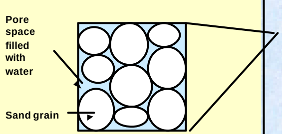
Depth to WT increases in dry season

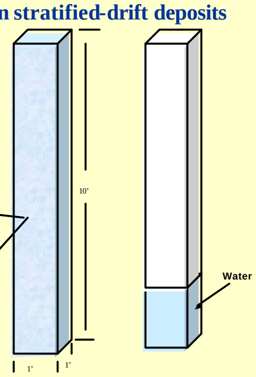
- Recharge < discharge
  - depth to WT increases
  - slope of WT decreases



Groundwater storage in stratified-drift deposits

10 cubic feet of well sorted, saturated sand with 20% porosity could store 2.0 cubic feet of water!

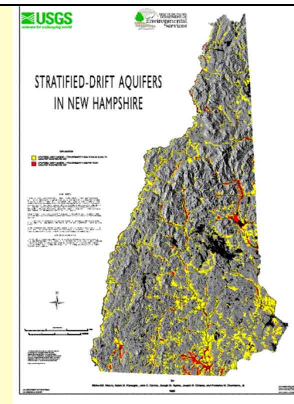




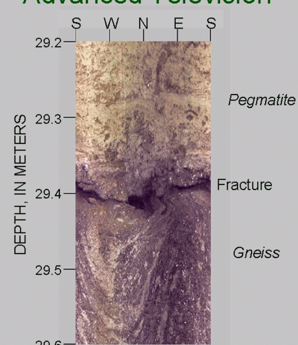
(NHGS, 2002)

•Approx. 14% of state covered by stratified-drift deposits

•Most urban centers and commercial/industrial development occupies areas of stratified-drift aquifers so future water supply potential may be limited



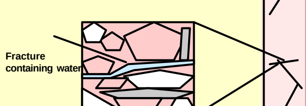
Advanced Television

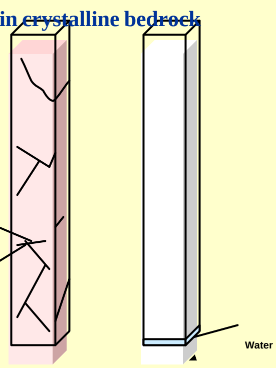


(USGS, 1998)

Groundwater storage in crystalline bedrock

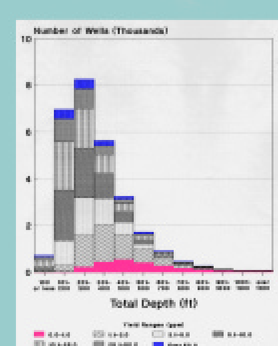
10 cubic feet of fractured, saturated granite with 2 % porosity could only store 0.2 cubic feet of water



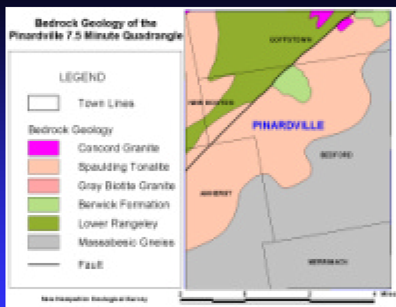


(NHGS, 2002)

Well yield as a function of total depth for 28,346 bedrock wells

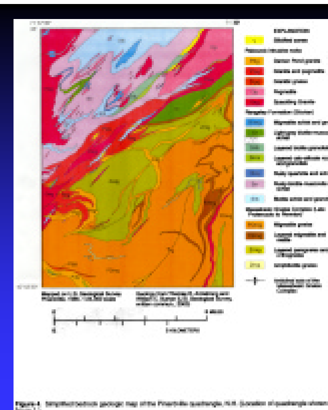


(NHGS, 2002)



Bedrock mapped at 1:250,000

(NHGS, 2002)



(USGS, 2001)

Trends in sustainability "variables"

New Hampshire is a popular place!

- State population grew by about 8.3% from 1990-1999
- 62 of the 234 NH municipalities grew by over 50% in the same period
- 10 of 234 grew by over 100%!

(NHOSP, 2002)

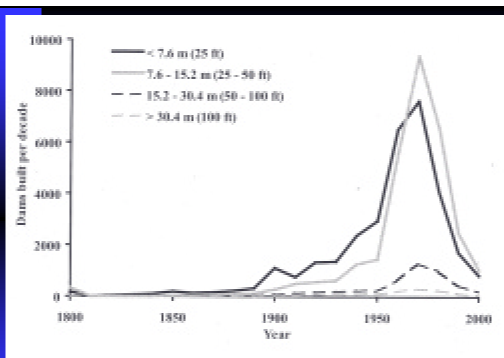
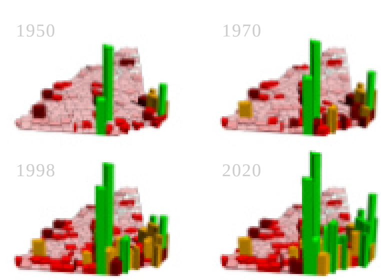


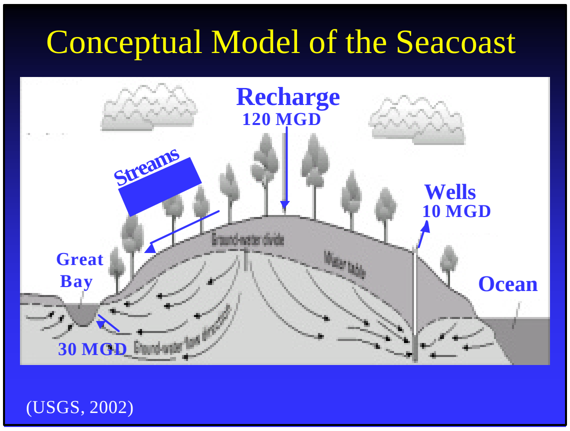
Fig. 1. Number of dams constructed over the past 200 years by decade and by National Inventory of Dams height class (FEMA, 1999). The most active period of dam building occurred between 1950 and 1970, and has been called "the golden age of dam building."

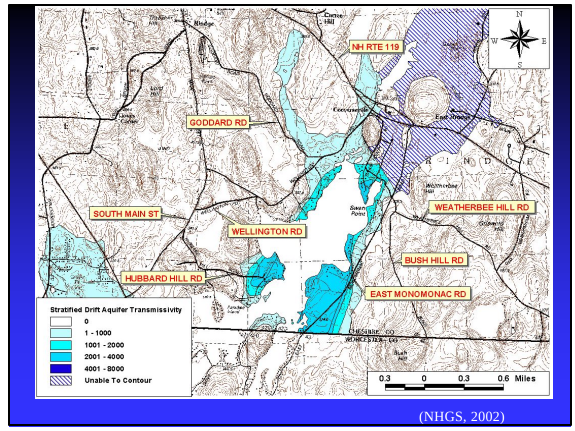
Population Density

Change: 1950 to 2020

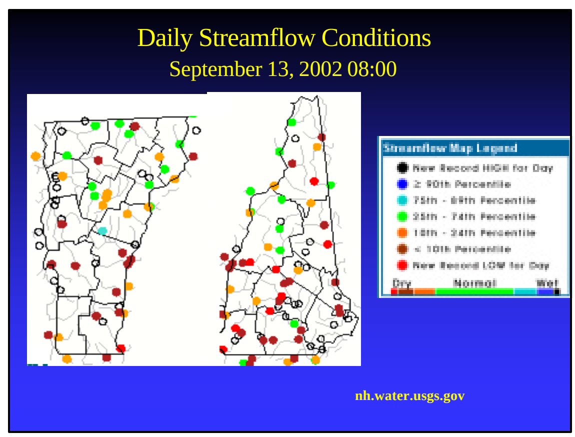


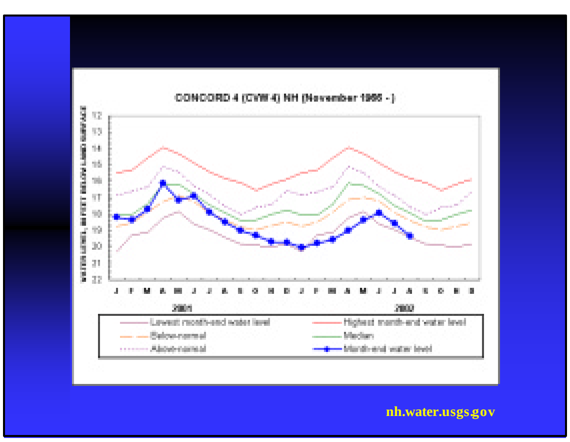
*Society for the Protection of New Hampshire Forests


Conceptual Model of the Seacoast
Recharge
120 MGD
Streams
Wells
10 MGD
Great
Bay
Ocean
30 MGD
(USGS, 2002)


NH RTE 119
GODDARD RD
SOUTH MAIN ST
WELLINGTON RD
WEATHERBEE HILL RD
BUSH HILL RD
HUBBARD HILL RD
EAST MONOMONAC RD
Stratified Drift Aquifer Transmissivity
0
1 - 1000
1001 - 2000
2001 - 4000
4001 - 8000
Unable To Contour
0.3 0 0.3 0.6 Miles
(NHGS, 2002)

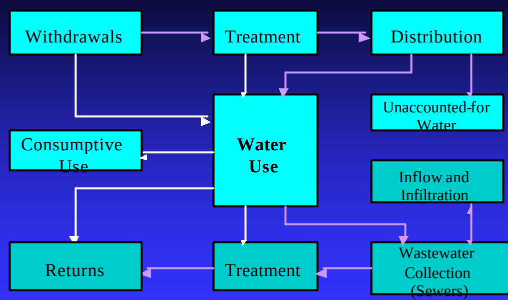

(USGS, 2000)


Daily Streamflow Conditions
September 13, 2002 08:00
Streamflow Map Legend
New Record HIGH for Day
≥ 90th Percentile
75th - 89th Percentile
25th - 74th Percentile
10th - 24th Percentile
< 10th Percentile
New Record LOW for Day
Dry Normal Wet
nh.water.usgs.gov


J F M A M J J A S O N D J F M A M J J A S O N D
2001
2002
Lowest month-end water level
Highest month-end water level
Below-normal
Median
Above-normal
Month-end water level
nh.water.usgs.gov


www.stateri.us/DEM/programs/bpoladm/suswshed/index.htm

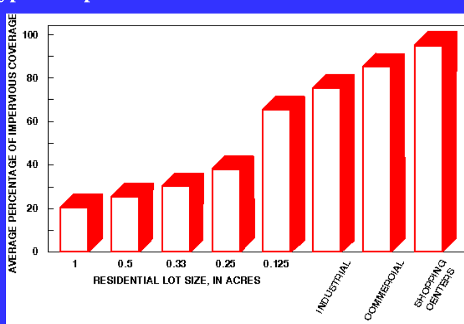
Complex Water Uses



nh.water.usgs.gov

www.stateri.us/DEM/programsbpoladm/suswshed/index.htm

Typical impervious covers for various urban land uses



(USGS, 2000)

Impervious surfaces & drainage systems

- decrease infiltration and recharge to groundwater
- provide an express route for runoff to waterways
- provide an express route for pollutants to waterways
- provide a surface for accumulation of pollutants
- prevent natural processing of pollutants in soil, plants

(USGS, 2000)

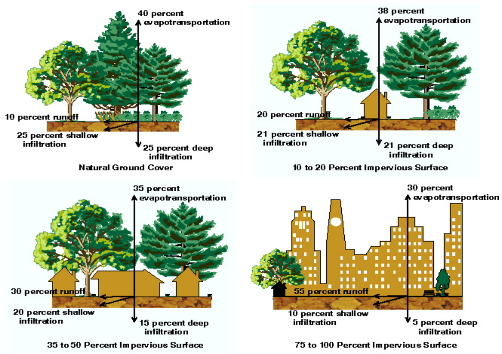
Some of the **big** unknowns:

- What is going on in the bedrock aquifer
  - Declining water levels?
  - Interconnection of fracture systems?
  - Ground-water capture?
- What is the interaction between the surficial aquifer and the bedrock aquifer?
- Aquifer compressibility?

(NHGS, 2002)

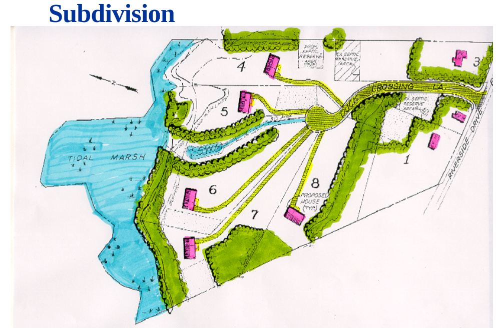
Steps toward achieving sustainability

Water cycle changes associated with urbanization



(USGS, 2000)

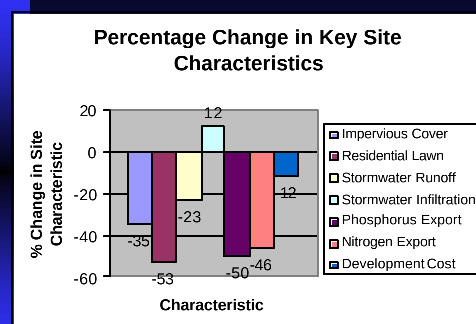
Example: Low-Density Conventional Subdivision



(NHDES, 2002)

Example: Conservation Subdivision

(NHDES, 2002)



(NHDES, 2002)

On the road to sustainability:

- Conservation
- Artificial recharge
- Shared investment in aquifer protection zones or infrastructure
- Water “recycling”

Artificial Recharge: Sustainable Source of Ground Water in a Fractured-Rock Aquifer

(Panda and others, 2002, NGWA Northeast FOCUS Conference)

It’s time to go from the slide show…..

to the road show….

Special Thanks:

- Tom Mack, Vt/Nh District USGS
- Rick Chormann and Derek Bennett, NH Geological Survey, NHDES